

EFFECTIVENESS OF NATIVE PARASITES AGAINST *AGROMYZA*
FRONTELLA (RONDANI) (DIPTERA: AGROMYZIDAE),
AN INTRODUCED PEST OF ALFALFA

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Abstract.—Fourteen species of native parasites of the alfalfa blotch leafminer, *Agromyza frontella* (Rondani), an introduced European pest, were recovered in the northeastern USA. Two additional species were recovered by cooperators in Canada. This complex of native parasites is poorly synchronized with the first 2 generations of the host, which may therefore reach economic injury levels; however, it gives satisfactory control of the next 3 generations. Season-long parasitism averaged 36%, but only 2% of the host puparia were parasitized. European host puparia collected in 1976-77 and shipped to the USDA quarantine facility at Newark produced 7 parasite species with a combined parasitism of 25.5%. All 7 species have been introduced in the USA.

The alfalfa blotch leafminer (ABL), *Agromyza frontella* (Rondani), is a European species first reported in North America in Massachusetts in 1968 (Miller and Jensen, 1970). It has since spread throughout the northeastern states (Hendrickson and Barth, 1978a) and into the adjoining Canadian provinces (Bereza, 1977). In North America, ABL is frequently an economic pest, though populations in Europe are usually held at low levels, with rare, localized outbreaks (Bollow, 1955).

We therefore surveyed the native North American parasites of ABL to determine their effectiveness and their phenology in relation to the host. Such information was useful in selecting parasite species from a large European complex, studied by personnel at the USDA European Parasite Laboratory, Paris, France, for possible introduction into the USA. The order, family, and identifier of species mentioned in this paper are presented in Table 1.

Sampling techniques.—Samples of 50 mined alfalfa leaflets, that is, leaflets visibly mined by any of the 3 agromyzid species present on alfalfa in the survey area (*Agromyza frontella*, *Liriomyza trifoliarum*, and *Liriomyza trifolii*) were collected randomly each week without regard for host species, instar, or condition of host from early May through November 1975 from each of 7 fields (1 at Newark, Del., 3 near Oxford, Pa., and 3 near Rancocas, N.J.). Collections were not made if the alfalfa was less than 12.7 cm (5 in.) high or bad weather interfered. The same procedure was followed in 1976 and 1977 except that in these years an additional field was surveyed in the

Table 1. Order, family, and identifier of species mentioned in this paper.

Species	
HYMENOPTERA: BRACONIDAE	
<i>Dacnusa dryas</i> (Nixon) ^a	
<i>Dapsilarthra balteata</i> (Thomson) ^d	
<i>Opius dureseai</i> Fischer ^a	
HYMENOPTERA: EULOPHIDAE	
<i>Achrysocharella Formosa</i> (Westwood) ^c	
<i>Chrysocharis clarkae</i> Yoshimoto ^e	
<i>Chrysocharis giraulti</i> Yoshimoto ^e	
<i>Chrysocharis punctifacies</i> Delucchi ^e	
<i>Closterocerus cinctipennis</i> Ashmead ^b	
<i>Closterocerus tricinctus</i> (Ashmead) ^b	
<i>Closterocerus utahensis</i> Crawford ^b	
<i>Diaulinopsis callichroma</i> Crawford ^f	
<i>Diglyphus begini</i> (Ashmead) ^e	
<i>Diglyphus intermedius</i> (Girault) ^b	
<i>Diglyphus pulchripes</i> (Crawford) ^b	
<i>Diglyphus websteri</i> (Crawford) ^f	
<i>Pnigalio minio</i> (Walker) ^e	
<i>Zagrammosoma multilineatum</i> (Ashmead) ^b	
HYMENOPTERA: PTEROMALIDAE	
<i>Cyrtogaster</i> sp. ^e	
<i>Halticoptera circulus</i> (Walker) ^e	
<i>Halticoptera laevigata</i> Thomson ^e	
<i>Miscogaster hortensis</i> Walker ^e	
<i>Miscogaster maculata</i> Walker ^e	
DIPTERA: AGROMYZIDAE	
<i>Agromyza frontella</i> (Rondani) ^c	
<i>Liriomyza trifoliarum</i> Spencer ^c	
<i>Liriomyza trifolii</i> (Burgess) ^c	

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Newark, Del., area. Also, collections were made weekly, from mid-April through July, and thereafter at 2-week intervals. However, if the abundance of leaflets containing mining larvae or *Liriomyza trifoliarum* puparia (the other 2 species pupate in the soil rather than in the leaflet) was low, the sample consisted of the number that could be collected in each field in 20 minutes. In the collections over the 3 years, ABL larvae were more abun-

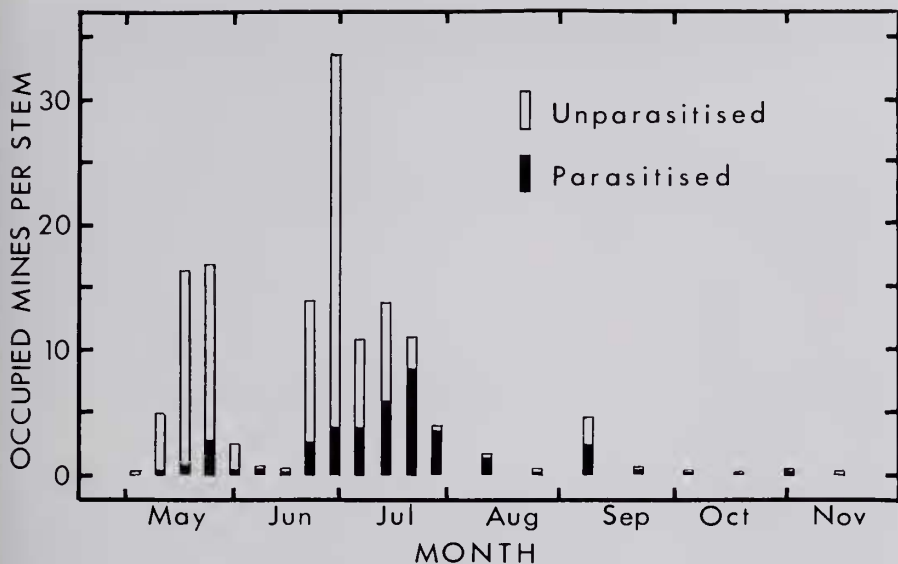


Fig. 1. Ratio of unparasitized to parasitized alfalfa blotch leafminer larvae related to number of occupied mines per stem for 1977. Larvae were collected on alfalfa at 2 fields in Newark, Del., 3 fields near Rancocas, N.J., and 3 fields near Oxford, Pa.

dant than larvae or puparia of *Liriomyza* spp. by ca. 9:1. In addition, we removed 20 stems from each field to determine the number of occupied and unoccupied mines per stem in 1977.

Some host characteristics.—There were 5 generations per year of ABL in the study area. Alfalfa is commonly cut 3 times each season in our area, the last time early in September, and a generation of ABL preceded each cutting. Then the alfalfa continues to grow until the end of November, so there is a period of nearly 3 months during which a 4th and possibly a 5th generation of the ABL can be produced. That these generations do occur was indicated by the presence of some active larvae and adult flies in the field up to the end of November. Pupating larvae of the 5th generation then emerged as adults in late April or early May of the following year. The major peak in population occurred at the time of the 2nd generation when 70+ mines per stem were sometimes encountered (Fig. 1).

Native parasite complex.—A total of 13,551 leaflets containing ABL larvae was placed in 5.08 cm (2 in.) diameter, tightly-sealed plastic petri dishes (one leaf per dish) with moistened filter paper on the bottom to maintain humidity. (So only a single host larva could be confined in each petri dish, any supernumerary insects were removed from the leaflet.) The petri dishes

Table 2. Parasite species and numbers reared from 13,351 alfalfa blotch leafminers collected in Delaware, southern New Jersey, and southeastern Pennsylvania in 1975-77.

Species	Recovered from		Total no.
	Larval stage	Pupal stage	
<i>Diglyphus intermedius</i>	x		1323
<i>Diglyphus pulchripes</i>	x		344
<i>Pnigalio minio</i>	x		152
<i>Diaulinopsis callichroma</i>	x		123
<i>Closterocerus tricinctus</i>	x		78
<i>Chrysocharis clarkae</i>	x	x	65
<i>Closterocerus cinctipennis</i>	x		58
<i>Achrysocharella formosa</i>	x		43
<i>Diglyphus websteri</i>	x		29
<i>Chrysocharis giraulti</i>	x	x	15
<i>Zagrammosoma multilineatum</i>	x		5
<i>Closterocerus utahensis</i>	x		2
<i>Halticoptera laevigata</i>		x	2
<i>Halticoptera circulus</i>		x	1
Unidentifiable ^a			69
	Total		2309

^a Adults were damaged or lost, or larvae were in diapause.

were then maintained at $20^{\circ}\text{C} \pm 1.1^{\circ}$ ($68^{\circ}\text{F} \pm 2^{\circ}$) with 14/24 h photophase. After 6 weeks, emerged parasite species were removed and identified. Initial recoveries were identified by authorities (see Table 1); subsequent recoveries were determined by comparison with identified specimens. Species recovered and numbers are listed in Table 2. Two species of parasites recovered from ABL from eastern Ottawa, Ontario, but not recovered by us in the USA, were the larval parasite *Diglyphus begini* and the larval-pupal parasite *Cyrtogaster* sp. (J. C. Guppy, pers. com.). *Diglyphus begini* was also recovered from ABL at St. Hyacinthe, Quebec (M. Guibord, pers. com.).

There was no emergence of either parasites or ABL from 52% of the mined leaflets. This was probably the result of many factors: early instars killed by probing (without oviposition) by the most abundant parasite, *Diglyphus intermedius* (Hendrickson and Barth, 1978b); overcrowding in the leaflet; host diapause; disease; predators; weather and other physical factors; insecticides; and possible deficiencies in our emergence technique.

At the peak of host larval populations in the 1st generation, an average of 11% of the larvae were parasitized (total live forms). The average was 16% in the 2nd generation. Parasites appeared 2-3 weeks too late in the spring to be effective against the 1st generation of ABL, and too few were present to control the 2nd host generation, when 70+ mines per stem were

Table 3. Parasite species and numbers reared from 33,573 alfalfa blotch leafminer puparia collected in Europe in 1976-1977 by personnel from the USDA European Parasite Laboratory, Paris, France. Parasites emerged in the quarantine facility at the USDA Beneficial Insects Research Laboratory, Newark, Delaware.

Species	No.	% of total parasites
<i>Chrysocharis punctifacies</i>	1656	42
<i>Dacnusa dryas</i>	1614	41
<i>Miscogaster maculata</i> , <i>M. hortensis</i>	571	15
<i>Opius dureseai</i>	47	1
<i>Halticoptera circulus</i>	26	<1
<i>Dapsilarthra balteata</i>	6	<1
Total	3920	

sometimes encountered. During the remaining 3 generations, the average parasitism was 55%, and the host populations remained well below the economic threshold. (A tentative economic threshold of 21% of the leaflets mined by a single larva has been established by R. A. Byers, pers. com.). Combined season-long parasitism was 36% (based on total emerged live forms; numbers of live forms varied for each host generation).

Of the 14 native species recovered from ABL, only 4 species emerged from ABL puparia (Table 2). These species emerged from 1.9% of the 4284 collected hosts which formed puparia.

Origin of the native parasite complex.—A likely explanation for the ABL parasites is adaptation from native agromyzids found on alfalfa. Therefore, petri dishes were set up as before, for 1566 leaflets containing larvae or puparia of *Liriomyza trifoliarum* or larvae of *Liriomyza trifolii* (the latter species pupates in the soil rather than the leaflet). All but 2 of the 14 parasite species recovered from ABL were also recovered from *Liriomyza* spp. The species not recovered were *Zagrammosoma multilineatum* and *Closterocerus utahensis*, which together accounted for only 0.3% of the parasitism of ABL. Possibly with more extensive surveys, these 2 species would also be recovered from *Liriomyza* spp.

We found that *Liriomyza* spp. on alfalfa are under excellent biological control. Season-long parasitism averaged ca. 63%. The complex of native parasites of ABL is therefore probably phenologically associated with that of *Liriomyza* spp.

European survey.—The USDA European Parasite Laboratory, Paris, France, provided us with 33,573 ABL puparia collected from France, Denmark, West Germany, Austria, Switzerland, and Liechtenstein in 1976-77. Parasites or ABL adults emerged from ca. ½ the puparia. Seven parasite species (Table 3) emerged from these collections, all of which have been

released in the USA with additional numbers shipped to us as adults. Parasitism of the pupal stage averaged 25.5%.

We therefore believe the introduction of parasite species capable of increasing parasitism of the pupal stage by 20–25% would reduce ABL to the extremely low population levels found in Europe. The most desirable species for establishment in the USA are *Chrysocharis punctifacies* and *Dacnusa dryas*, which together accounted for 83% of the parasites emerging from European puparia. These species have been established in Delaware (Hendrickson, 1978).

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